AB INTERNO PULSED DYE LASER SCLEROSTOMY FOR THE TREATMENT OF GLAUCOMA: PRELIMINARY RESULTS OF A NEW TECHNIQUE

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SUMMARY

***Ab interno* gonioscopic laser sclerostomy in conjunction with iontophoretic staining of the sclera was performed on 12 patients with end-stage glaucoma in order to ascertain the feasibility of the technique. In 9 of 12 patients (75%) a visible sclerostomy was formed and mean intraocular pressure (IOP) dropped from 36.3 mmHg prior to treatment to 25.3 mmHg at 1 week, a fall of 30.3%. The drop in IOP was maintained throughout a 3-month follow-up period, with 6 of 11 patients having IOP controlled below 21 mmHG. The procedure is described together with our preliminary results, and possible advantages and areas of improvement for the technique are discussed.**

Trabeculectomy is currently the commonest procedure for the surgical management of glaucoma. However, surgical trauma to the conjunctiva with subsequent fibroblast proliferation and scarring of the bleb results in failure to control intraocular pressure in a proportion of cases.[1,2] An ideal procedure would be one that produces a relatively non-invasive sclerostomy, with little adjacent tissue damage or conjunctival dissection, thus minimising scar formation.

The use of lasers in glaucoma surgery to alter trabecular outflow resistance dates back 20 years.[3] More recently interest has once more focused on the use of lasers to produce either full-thickness sclerostomies or trabeculotomies. Nd-YAG[4–6], argon,[7] carbon dioxide,[8] holmium-YAG,[9] excimer[10] and erbium-YAG lasers[11] have all been used for this purpose. These techniques still either require an incision into the anterior chamber or through the conjunctiva, or use very high energy with subsequent inflammation and possible scarring. The total energy required to produce a full-thickness sclerostomy can be reduced by preliminary staining of the sclera.[12] The use of a pulsed-dye laser in conjunction with iontophoretic staining of the sclera[13] allows *ab interno* sclerostomy to be performed via a gonioscopic approach and therefore eliminates the need for any surgical manipulation of the ocular tissues, whilst minimising the energy used. This technique has been studied in monkey, rabbit and human eyes.[13–15]

The aims of this preliminary report are to establish whether a full-thickness sclerostomy can be produced using an *ab interno* approach, to investigate its effect on intraocular pressure, and to document the results of *ab interno* sclerostomy in a series of patients with end-stage refractory glaucoma.

MATERIALS AND METHODS

Patients entering the study fulfilled the entry criteria of visual acuity of Counting Fingers or less and all had an intraocular pressure (IOP) greater than 23 mmHg. A clear cornea permitting an accurate view of the drainage angle was essential. There was an age range of 35–82 years (mean 67 years). For each patient previous surgery, number of glaucoma medications and type of glaucoma were recorded. Laser sclerostomy was only performed after full informed consent regarding the procedure and possible side effects. Ethics committee approval was obtained before commencing the study.

Procedure. A retrobulbar anaesthetic of 2% lignocaine/0.5% bupivacaine was used prior to laser treatment.

Iontophoresis of Sclera. Following retrobulbar anaesthesia and topical application of amethocaine 1% a lid speculum was inserted with an alligator clip connected to the earth pole of the iontophoresis power supply. The live pole was connected to a wire running through the iontophoresis tip containing either reactive black or methylene blue dye. The iontophoresis probe was then applied to the conjunctiva just posterior to the limbus at the proposed sclerostomy site. The duration of iontophoresis was 5 minutes with a current of 500 microamps. The pen-

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Table I. Summary of patient characteristics

Patient no.	Sex	Age (yr)	Operated eye	Diagnosis	No. of drugs	Cup–disc ratio	Visual acuity
1	F	76	L	PXF	2	0.8	PL
2	M	65	L	Rubeotic	1	0.9	NPL
3	M	82	L	COAG	1	0.9	HM
4	M	35	R	CNAG	0	—	NPL
5	M	80	L	COAG	0	0.8	NPL
6	M	49	L	Angle recession	1	1.0	CF
7	M	75	R	COAG	2	1.0	NPL
8	F	73	R	PXF	0	0.9	PL
9	M	76	R	COAG	1	1.0	NPL
10	M	56	L	COAG	1	0.9	PL
11	M	68	R	COAG	0	1.0	NPL
12	F	66	R	POST. RD	0	—	HM
Average		67			0.75	0.9	

F, female; M, male; L, left; R, right; PXF, pseudoexfoliation; COAG, chronic open angle glaucoma; Post. RD, posterior retinal detachment; PL, perception of light; NPL, no perception of light; HM, hand movement; CF, counting fingers.

etration of dye through the sclera was checked with a goniolens at the slit lamp. Following iontophoresis a conjunctival bleb was raised with normal saline through a 30 gauge needle.

Laser Delivery. The laser used was the flashlamp-excited pulsed dye laser (Candela Corp.) emitting red light of wavelength 590 nm with pulse duration of 7 μs and spot size of 200 μm. The energy range available is 50–300 mJ per pulse. The laser light is administered via a modified Haag-Streit goniolens through a slit lamp delivery system. An initial energy of 200 mJ was used to disrupt Descemet's membrane, followed by a maximum of 50 pulses of 250–300 mJ until a sclerostomy was produced. The sclerostomy was performed anterior to Schwalbe's line.

Post-operative Follow-up. All patients received gtt. prednisolone 0.5% q.d.s. to the treated eye for 7 days. IOP was recorded at 1 hour, 1 day, 1 week and 1 month after treatment. The number of antiglaucoma drops used was also recorded. At each visit the presence of a fistula was established gonioscopically and the presence or absence of a conjunctival bleb noted. Any complications were recorded.

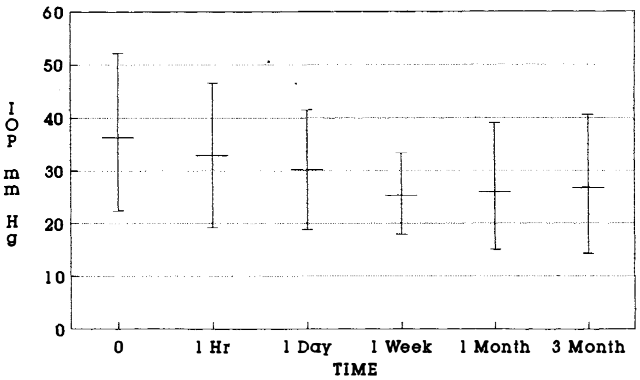

Fig. 1. *Intraocular pressure versus time. Horizontal lines are the mean and vertical bars ± 1SD.*

RESULTS

All patients had end-stage glaucoma with a visual acuity of Counting Fingers or less. In 6 cases the diagnosis was chronic open angle glaucoma; other causes included pseudoexfoliation (2 cases), chronic narrow angle glaucoma, post-traumatic angle recession, post-retinal detachment and neovascular glaucoma (1 case each). All eyes were phakic and none had undergone previous antiglaucoma surgery. All had cup–disc ratio of 0.8 or greater.

In 6 patients reactive black dye was used to stain the sclera and methylene blue was used in the other 6. The reactive black dye formed a more discrete area of stain compared with the diffuse staining pattern of the methylene blue. In 2 cases the stain intensity was inadequate and prevented the completion of a full-thickness sclerostomy.

The results are summarised in Tables I and II and Figs. 1 and 2. The mean IOP prior to treatment was 36.3 mmHg. This fell over the first week to a mean of 25.3 mmHg (a fall of 30.3%), the fall being sustained over the 1 and 3 month follow-up periods ($P<0.005$, paired *t*-test). At the 3 month follow-up assessment 1 patient failed to attend. Of the remaining 11 patients, 10 (91%) showed a persistent decrease in IOP ranging from 4 to 29 mmHg (mean 11.5 mmHg), and 6 of 11 patients had an IOP below 21 mmHg (Fig. 2).

In 6 of 12 patients (50%) a shallow bleb was present at 24 hours after treatment. However, this was not a prerequi-

Table II. Summary of results

Patient no.	Stain[a]	Total energy (J)	Visible sclero-stomy?	Bleb?	Intraocular pressure (mmHg) at: 0	1 hour	1 day	1 week	1 month	3 months	Complications
1	3 MB	6.5	+	±	45	44	46	27	22	16	Hyphaema +
2	3 RB	9.2	–	–	30	30	30	30	30	25	Hyphaema +++
3	3 RB	6.75	+	±	28	28	32	21	20	18	Oedema
4	3 MB	9.5	+	+	32	20	24	20	14	44	Conjunctival defect, iridotomy
5	3 MB	10.3	+	+	48	52	36	30	33	34	Epithelial burn
6	3 RB	12.9	+	+	28	26	20	15	15	16	Iris atrophy
7	3 MB	8.2	+	–	24	30	28	21	24	20	Epithelial burn, oedema
8	2 MB	9.25	+	–	75	56	48	43	56	55	Iris peak
9	1 RB	1.2	+	–	24	16	12	26	18	18	Epithelial burn
10	3 RB	14	+	–	38	18	18	19	36	28	
11	2 MB	4.5	–	+	26	34	30	23	20	20	
12	3 RB	17.2	–	–	38	42	38	30	30	DNA	
Mean		9.1			36.3	32.9	30.1	25.3	25.9	26.7	

[a]1–3, stain intensity; MB, methylene blue; RB, reactive black.

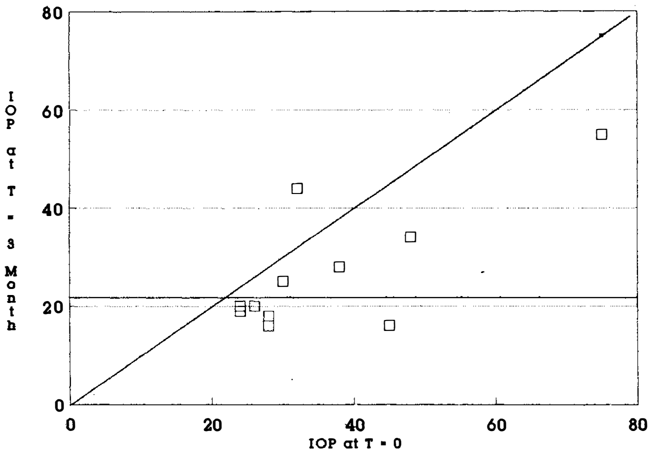

Fig. 2. *Intraocular pressure before treatment (T = 0) and 3 months after treatment.*

site for a fall in IOP, which was seen in the majority of cases at 24 hours and in all except 1 patient at 1 week after treatment. The type of bleb seen was not typical of other filtration techniques but consisted of a shallow, diffuse elevation of the conjunctiva. At 1 month none of the eyes showed an obvious bleb despite maintaining the fall in IOP.

At the time of treatment it was difficult to establish an end point due to poor visibility from debris or, in those cases affected, to loss of corneal clarity. For this reason the number of pulses and therefore energy used varied between 1.2 and 17.6 J. In one case gas bubbles appeared in the subconjunctival bleb. Shallowing of the anterior chamber did not occur.

Complications

Debris, cells and flare occurred to some degree in all cases immediately following the procedure. These had resolved within 1 week in all cases.

Hyphaema occurred in 2 eyes. In 1, a small iris vessel bled during the procedure and the hyphaema settled within 24 hours. The other case was a patient with rubeosis who developed a 4 mm hyphaema at day 1.

In 3 patients corneal epithelial burns occurred during the laser treatment, which in 2 cases necessitated ending the procedure. Some patient discomfort occurred when the anaesthetic had worn off but all healed within 24 hours. This complication could be the result of dye particles from the iontophoresis remaining in the precorneal tear film and taking up the laser energy.

Two patients had mild epithelial oedema on the first day following treatment which made assessment of the sclerostomy difficult. The eye with narrow angle glaucoma suffered an iridotomy (but this relieved the iris bombe and led to a deepening of the anterior chamber). One other eye had a small iris burn with atrophy evident at 24 hours. This eye also had a tear in Descemet's membrane at the site of sclerostomy.

One patient developed a conjunctival defect at the iontophoresis site, but despite a significant pressure drop there was no Seidel-positive leak and this had healed by 24 hours.

DISCUSSION

The results we have obtained so far with the technique show that it is feasible to produce a full-thickness or partial sclerostomy with subsequent reduction in IOP, and minimal inconvenience to the patient. If effective in lowering IOP in the long term, the technique has many potential advantages over both surgical and other laser drainage procedures in respect of its relatively non-invasive nature, the overall cost of each treatment, patient comfort and the fact that hospitalisation is unnecessary.

There are a number of difficulties associated with the technique, including the fact that the end point of the procedure is difficult to assess and the amount of energy necessary to form a sclerostomy may therefore be less than we have used in these preliminary studies. Unlike other sclerostomy techniques there is no sudden loss of anterior chamber depth during the procedure and IOP may subsequently fall in the following days despite a minimal change at the time.

The gonioscopic *ab interno* approach eliminates the need for conjunctival dissection and the subsequent fibrosis which may be responsible for early bleb failure in conventional filtration surgery.[1,2] The technique is non-invasive and therefore likely to be safer than procedures that require an intraocular approach.

In contrast to the holmium laser *ab externo* technique, iris incarceration and anterior chamber shallowing were not a problem.[9] This may be due to the shape and size of the sclerostomy leading to a 'valve' effect and more controlled filtering of aqueous, or to the fact that a partial-thickness rather than a full-thickness sclerostomy is created. In addition the sclerostomy is placed relatively anteriorly and its position can be carefully selected.

It is evident that in order to accomplish a sclerostomy there must be good iontophoretic staining of the sclera and a clear cornea to allow adequate uptake of laser energy.

There were few minor complications recorded, which included corneal burns and oedema, localised trauma to the iris, uveitis and hyphaema. All these settled within the first week following treatment. We now consider neovascular glaucoma a contraindication for the procedure.

In some cases IOP was lowered despite the failure to produce a full-thickness sclerostomy or in the absence of a visible bleb. In such cases other mechanisms may be involved, such as a complete but narrow sclerostomy allowing filtration of aqueous but no bleb formation, a cyclodialysis effect, a trabeculotomy effect with communication into Schlemm's canal, or reduced aqueous production from either direct laser trauma or subsequent uveitis.

Further refinement of the technique may improve the effectiveness of this form of treatment. Possible modifications include the position of iontophoresis and choice of dye, the angle of the laser beam and thus the sclerostomy, the size of the sclerostomy and whether antimetabolites have a role as they do in conventional surgical techniques.[16] Since the size of the fistula is small (200–300 μm)[14] it is likely to have a high potential for closure.

In conclusion, *ab interno* laser sclerostomy provides a safe, relatively non-invasive procedure which is quick, can be performed in the outpatient clinic and can be repeated if necessary. These are our first experiences with a new technique and further studies will be needed to establish whether it has a future role in the management of glaucoma.

Key words: *Ab interno* sclerostomy, Glaucoma, Pulsed dye-laser.

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